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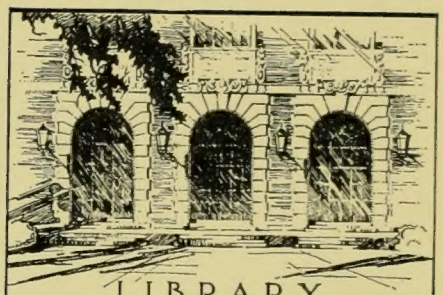

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ECTOPARASITES OF THE COTTONTAIL RABBIT

In Lee County, Northern Illinois

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Fig. 1.—A favorable habitat for cottontail rabbits in Illinois.

Ectoparasites of the Cottontail Rabbit In Lee County, Northern Illinois

Lewis J. Stannard, Jr.,* and Lysle R. Pietsch†

Of the wild animals in Illinois, the eastern cottontail rabbit, *Sylvilagus floridanus mearnsii* (Allen), is the species most commonly hunted and handled by human beings. Because rabbits are carriers of the virulent disease tularemia, which is transmitted from rabbit to rabbit by certain ectoparasites and from rabbits to men by handling, the ectoparasites of these animals are of considerable importance to human beings as well as to rabbits.

A few years ago, ectoparasites of Illinois cottontails received limited investigation by Ecke (1948) and by Ecke & Yeatter (1956). About the same time, Yeatter & Thompson (1952) published an analysis of rabbits, their ectoparasites, and their diseases in relationship to weather and man. These studies served to bring new attention to the many gaps in knowledge of the seasonal activity and abundance of the ectoparasites of rabbits.

When an opportunity arose in 1952 to make further observations on rabbits and their ectoparasites as part of a larger study of management of cottontails, a study designated as Project No. 42-R and set up under terms of the Federal Aid in Wildlife Restoration Act,‡ the authors joined forces in the hope that some new facts might be discovered that would fill one or more of these gaps. We realized that only part of our time could be devoted to this work and that our treatment necessarily would be brief. Principally, we hoped to learn the exact period in the year rabbits are free of ticks and consequently free of tularemia. We learned this and more. We noted unsuspected behavior patterns of the adult continental rabbit tick *(Haemaphysalis leporis-palustris)*, seasonal fluctuations of the common eastern rabbit flea *(Cediopsylla simplex)*, and additional facts concerning these and other ectoparasites. Herein is the report of our observations and of the collections on which they were based.

Acknowledgment is made to Drs. Harlow B. Mills, Herbert H. Ross, Thomas G. Scott, Ralph E. Yeatter, and Carl O. Mohr, Mrs. Leonora K. Gloyd, Mrs. Diana R. Braverman,. and James S. Ayars, all of the Illinois Natural History Survey, for advice concerning interpretations and presentation of the data. Identification of some of the fleas was made or confirmed by G. P. Holland of Ottawa, Ontario. The photographs were taken by William E. Clark of the Illinois Natural History Survey. We are indebted to Glenn Haas, who has made a similar study in Wisconsin, for suggestions and constructive criticisms.

SCOPE OF STUDY

Field work was conducted near Amboy, Lee County, on farm lands and idle fields, many of them similar to the field shown in fig. 1. Lee County is typical of most of northern Illinois. Here rabbits from two areas, each of about 1 square mile, were examined. One area consistently had a much higher average per-acre population of cottontails than the other. The area with the greater number of rabbits yielded a greater number of ectoparasites. In this report, data from the two areas are combined.

Most of the rabbits examined were trapped alive, examined alive, and released. The ectoparasites were removed in the field, often as late as several hours after the rabbits were captured. Undoubtedly some ectoparasites were missed, such as those deep in the ears, but probably a large majority of the ticks and fleas were taken. Presumably not enough were overlooked to alter our conclusions appreciably. Nevertheless, the reported percentages of rabbits infested by each species of ectoparasite and the average numbers of ectoparasites per rabbit should be regarded as minima.

The junior author collected over 10,000 ectoparasites from more than 700 rabbits in the period beginning May, 1952, and ending November, 1954. Collecting varied in intensity according to the time that could be given to the study. The senior author sorted, identified, and counted the ectoparasites.

Occasionally a rabbit was caught several times within a season. For example, a rabbit designated as Peter II was caught nine times in July and August, 1952, and each time all the ectoparasites found on it were removed and preserved. Other rabbits, No. 57 and No. 307, were caught five times each; several were caught four times; and as many as 30 were caught two or three times within a 2-month period.

Additional material from rabbits from southern Illinois (Jackson and Union counties) was gathered by Dr. Willard D. Klimstra of Southern Illinois University

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‡ The Illinois Department of Conservation, the United States Fish and Wildlife Service, and the Illinois Natural History Survey, co-operating.

and Glen C. Sanderson, the latter employed jointly by the Illinois Department of Conservation and the Illinois Natural History Survey. These collections, together with those gathered from many other areas by Survey staff members, were compared with the data obtained from Lee County in northern Illinois to secure information on the differences in the seasonal behavior of rabbit ectoparasites within the various climatic zones of Illinois. Illinois, a long state, extends about 380 miles from north to south and embraces several climatic and life zones.

Cottontails in Illinois are the normal hosts to at least seven species of facultative or obligate ectoparasites, exclusive of chiggers and other small mites. Infrequently, perhaps accidentally, rabbits of Illinois may acquire other species of ticks and fleas that regularly feed on other mammals, such as ground squirrels, mice, and moles, but these ectoparasites do not usually persist on rabbits.

Rabbits in the western part of North America are hosts to several more, most of them different, species of ectoparasites than are rabbits in the eastern part, table 1. Often where one species of ectoparasite drops out at the edge of its range, another biologically equivalent species takes over and continues into the adjacent geographical range. There is a sudden change in the kinds of species of ectoparasites on rabbits at about the 100th meridian. Cottontails in Illinois are infested by every rabbit ectoparasite known east of the 100th meridian except the flea *Hoplopsyllus (Euhoplopsyllus) glacialis affinis* (Baker). To date, no specimens of *affinis* have been taken in Lee County or elsewhere in Illinois.

TICKS

***Haemaphysalis leporis-palustris* (Packard); continental rabbit tick, rabbit tick; fig. 2.** – When ranked according to numbers of individuals collected within a period of a year, the continental rabbit tick stands as the principal ectoparasite of cottontails in Illinois. This tick is also apparently the chief carrier from rabbit to rabbit of the organism, *Pasteurella tularensis*, that produces tularemia, a disease which is invariably fatal to rabbits (Green 1939).

Although the continental rabbit tick is common over much of North America and all of Illinois, fig. 3, and is collected frequently by biologists, many aspects of its life history are poorly known.

We found and others have reported that individuals of this tick feed mostly on the rabbit's head, particularly on and in the ears, on the back of the neck, and sometimes around the eyes and nose and under the chin.

Hooker *et al.* (1912) were among the first to publish detailed biological information on this tick. According to their findings in Texas, "The three stages of the rabbit tick have been taken from hosts in nature during all seasons of the year."

According to a number of authors, the continental rabbit tick in areas north of Texas, specifically in Okla-

Table 1.–Distribution of the common ectoparasites of rabbits in the United States, exclusive of chiggers, small mites, and nest inquilines.

Group	Species Found East of 100th Meridian	Species Found West of 100th Meridian	
		North	South
Ticks	*Haemaphysalis leporis-palustris* *Ixodes dentatus* *Dermacentor variabilis*	*Haemaphysalis leporis-palustris* *Ixodes spinipalpis* *Dermacentor andersoni* *Otobius lagophilus*	*Haemaphysalis leporis-palustris* *Ixodes neotomae* *Dermacentor parumapertus* *Ornithodoros turicata*
Fleas	*Cediopsylla simplex* *Odontopsyllus multispinosus* *Hoplopsyllus glacialis affinis* (Apparently rare east of Mississippi River; taken from imported Kansas cottontails in New Jersey, Burbutis & Mangold 1956)	*Cediopsylla inaequalis* *Odontopsyllus dentatus* *Hoplopsyllus glacialis affinis*	*Cediopsylla inaequalis* *Odontopsyllus dentatus* *Hoplopsyllus glacialis affinis* *Hoplopsyllus foxi*
Bot Flies	*Cuterebra buccata* *Cuterebra horripilum* *Cuterebra cuniculi*	*Cuterebra leporivora* *Cuterebra lepusculi*	*Cuterebra leporivora* *Cuterebra lepusculi*
Lice		*Haemodipsus setoni*	*Haemodipsus setoni*

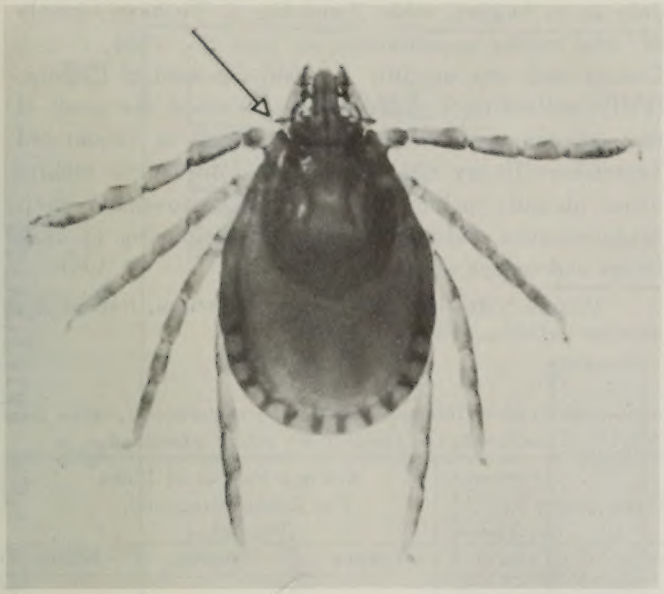

Fig. 2.—*Haemaphysalis leporis-palustris*, continental rabbit tick, unengorged adult female. This tick is a vector of tularemia. The characteristic of sharply pointed, lateral angles near the base of the mouthparts (one indicated by arrow) is distinctive of this tick in all stages.

homa, Missouri, Iowa, Montana, and Minnesota, is not equally abundant on rabbits at all seasons, and, furthermore, one or more of the stages are often rare to absent at certain seasons. Even in Florida the continental rabbit tick is noticeably less abundant in winter (Hixon in Eddy 1942).

Apparently the more northerly the region the more markedly the populations of this tick fluctuate on rabbits with the seasons. In Oklahoma (Eddy 1942) and in southern Missouri (Portman 1944), this tick occurs occasionally on rabbits even in midwinter. By contrast, in northern Missouri (Portman 1944), Iowa (Joyce & Eddy 1943), Montana (Cooley 1932), and Minnesota (Green *et al.* 1943), it becomes scarce on or entirely absent from rabbits during the coldest winter months.

In Minnesota, Green *et al.* (1943) found that larvae of *Haemaphysalis leporis-palustris* "suffer a relatively enormous loss as compared with the losses among older ticks, and that the total winter mortality can be accounted for largely on the basis of deaths of larval ticks." In Iowa, Joyce & Eddy (1943) reported an abrupt decrease to very few larvae on rabbits in November, an absence of larvae in December, and a low prevalence of larvae on rabbits in April, May, and June. Apparently in Iowa, as in Minnesota, many unfed larvae fail to survive the winter.

Hooker *et al.* (1912) observed that under favorable conditions ticks in the larval stage could survive as long as 258 days (about 8 months) without feeding. They found, however, that most larvae survived for 2 to 7 months.

In this study, we found that continental rabbit ticks came out of hibernation earlier in southern Illinois than in Lee County. An observation of winter activity was made by Glen C. Sanderson in Union County, southern Illinois. There he found, on December 21, 1955, an adult rabbit tick feeding on a swamp rabbit, *Sylvilagus aquaticus aquaticus* (Bachman). In southern Illinois, adults appeared regularly in some abundance on rabbits at the end of January. Our earliest records of the year for rabbit ticks in Lee County were of adults collected on February 25, 1953, and February 17, 1954.

When the warmer weather of spring arrived, increasing numbers of both adults and nymphs of the continental rabbit tick were found attached to rabbits in Lee County, fig. 4. By mid-April copulating pairs were observed on their hosts. By July the numbers of adults had decreased. Adults seldom were found on rabbits in Lee County in autumn or the first part of winter. Only one adult was found on these rabbits in fall. This specimen was taken on November 9, 1954. Although rarely on rabbits in autumn and winter, adults were present in the surroundings and were taken repeatedly in September, October, and November from leaf mold.

During the several winter and spring months in which we examined rabbits for ticks in Lee County, we found no larvae of the continental rabbit tick. We learned,

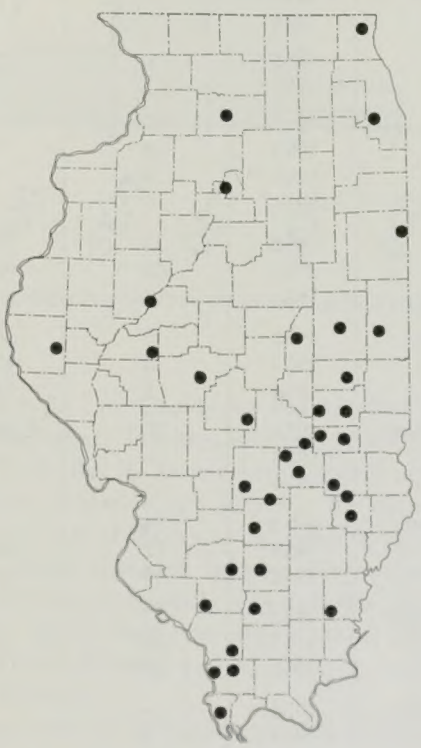

Fig. 3.—*Haemaphysalis leporis-palustris* distribution in Illinois, based on Illinois Natural History Survey records.

however, of a record of larvae from a towhee, *Pipilo erythrophthalmus*, collected on May 14, 1951, at Zion, a northeastern Illinois town near the Wisconsin border. Dr. S. Charles Kendeigh, an ornithologist at the University of Illinois, believed that, because of the late date, this towhee was a resident bird and had not recently arrived. It is possible that the towhee acquired the ticks at Zion rather than from some southern area. Seemingly, the larvae on the towhee survived a northern Illinois winter in an unfed condition. Larvae began to appear on rabbits in Lee County in the latter half of July or in August, table 2 and fig. 4. We have records of one earlier appearance, on June 25, 1954, in Lee County and one on July 5, 1946, in central Illinois, (INHS collection*). Larval ticks reached the peak of their abundance on rabbits in Lee County in August and September. Heavy concentrations of larvae on rabbits ended abruptly in late October or early November, their disappearance coinciding with the beginning of deep frosts and colder weather.

*Illinois Natural History Survey collection, Natural Resources Building, Urbana, Illinois.

Table 2.—Number of larvae, nymphs, and adults of the continental rabbit tick, *Haemaphysalis leporis-palustris*, taken from cottontails examined in Lee County, Illinois; also, the average number of each stage of the tick per rabbit examined.

Month	Year	Number of Rabbits Examined	Number of Ticks Taken			Average Number of Ticks Per Rabbit Examined, 1952–1954		
			Larvae	Nymphs	Adults	Larvae	Nymphs	Adults
January	1952	—	—	—	—			
	1953	9	0	0	0	0.0	0.0	0.0
	1954	1	0	0	0			
February	1952	—	—	—	—			
	1953	113	0	0	1	0.0	0.0	0.1
	1954	40	0	0	20			
March	1952	—	—	—	—			
	1953	11	0	89	123	0.0	8.0	11.2
	1954	—	—	—	—			
April	1952	—	—	—	—			
	1953	5	0	14	133	0.0	2.8	26.6
	1954	—	—	—	—			
May	1952	4	0	2	6			
	1953	12	0	195	104	0.0	12.3	6.9
	1954	—	—	—	—			
June	1952	52	0	36	221			
	1953	9	0	17	142	0.01	1.5	6.7
	1954	6	1	50	87			
July	1952	13	0	0	2			
	1953	63	852	26	173	10.6	0.4	2.5
	1954	4	0	6	23			
August	1952	15	260	39	3			
	1953	8	173	5	7	19.6	4.0	0.4
	1954	5	116	69	2			
September	1952	77	2,433	922	1			
	1953	—	—	—	—	31.6	12.0	0.01
	1954	—	—	—	—			
October	1952	74	7	64	0			
	1953	72	388	957	0	3.1	7.0	0.0
	1954	19	117	146	0			
November	1952	37	6	11	0			
	1953	38	21	63	0	0.3	0.88	0.01
	1954	26	11	15	1			
December	1952	—	—	—	—			
	1953	2	0	0	0	0.0	0.0	0.0
	1954	—	—	—	—			
TOTAL		715	4,385	2,726	1,049			

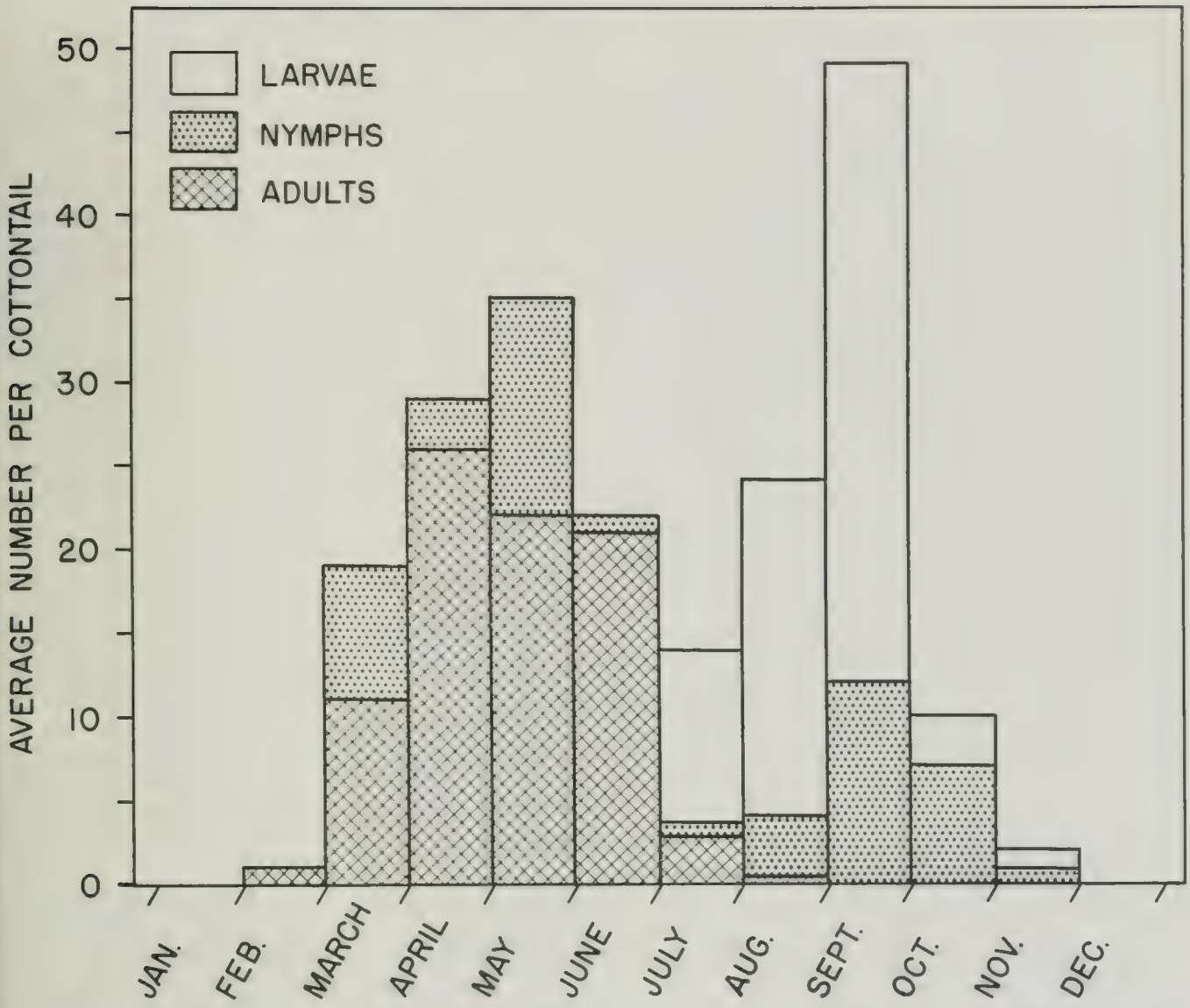

Fig. 4.—Monthly average of larvae, nymphs, and adults of *Haemaphysalis leporis-palustris* found on rabbits examined in Lee County, Illinois, 1952-1954. The graph is based on data in table 2.

Nymphs of the year appeared on Lee County rabbits from about the middle of August until about the middle of November, table 2 and fig. 4. They became most abundant in September and the first half of October. Like the larvae, the nymphs became scarce and disappeared from rabbits at the onset of cold weather, but, unlike the larvae, the nymphs commonly survived the winter in a state of hibernation and reappeared on rabbits in the spring. August 1, 1953, was our latest seasonal record for a nymph presumed to be of a generation started in the previous year. Because nymphs eventually transform into adults or perish, it is not surprising that a decline in the numbers of nymphs collected occurred in June.

Illinois seems to be wholly in the region wherein continental rabbit ticks are generally absent from rabbits in winter. In Lee County we did not find ticks on rabbits in December, January, or most weeks of February, table 2 and fig. 4. In southern Illinois we have a few records of limited winter activity. We have no records, from any part of the state, of ticks being on their hosts during most weeks of January, the coldest month of the year. On the other hand, it is probable that during warm winter spells some of these ticks, especially those in southern Illinois, may be quick to come out of hibernation to feed.

If it were not for literature records of larvae surviving the winter in Montana, Minnesota, Iowa, and possibly even Alaska (Philip 1939), we would have suspected from our data that extremely few larvae of the continental rabbit tick can overwinter in northern

Illinois. Although some larvae survive, winter cold may take, directly or indirectly, a heavy toll of unfed larvae.

Apparently, some larvae do not survive much more than a few months in an unfed state (Hooker *et al.* 1912). Because the larvae in Lee County are probably at least 2 months old by late fall, many of those that have not found a host before the beginning of winter may be supposed to perish from starvation. The nonlethal starvation period possible for most larvae may terminate at about the time temperatures drop in winter. At this time larvae, numbed by cold and unable to seek a host, may die from lack of food rather than from cold directly. The extent to which cold alone or combined with other factors may adversely affect unfed larvae is an unsolved problem that is worthy of future investigations.

Low temperatures may influence adults as well as larvae. Adults of the continental rabbit tick, in both the north and south, go into hibernation or into a period of rest even before the advent of cold weather. Possibly they require a period of rest or subjection to low temperatures before they are able to feed, mate, and lay eggs. Such seems to be the case with adults of the eastern rabbit tick, *Ixodes dentatus*, which, according to Smith (1945), must undergo hibernation in the unengorged state for one winter before they will feed. Similar behavior may be inherent in the continental rabbit tick. If so, the termination of this rest period may come about during the winter. Because of a longer period of low temperatures in the north, adults there would necessarily wait longer before seeking a new host than would adults in the south. We made no observations on whether the photoperiod affected the activity of the adults.

It is presumed that in Lee County most rabbits become hosts to rabbit ticks at some time, if not many times. For example, between August 11 and August 30, 1952, one rabbit, designated as Peter II, was infested with at least 60 ticks in the following sequence: August 11, 6 ticks; August 18, 13 ticks; August 21, 11 ticks; August 22, 0 ticks; August 25, 10 ticks; August 27, 14 ticks; and August 30, 6 ticks. Other rabbits may encounter continental rabbit ticks as frequently as did Peter II.

The proportion of rabbits in Lee County infested with the continental rabbit tick varied greatly with the season. During the period of greatest tick abundance, August and September, nearly 90 per cent of the rabbits examined had one or more ticks. By contrast, from late fall through the coldest part of winter, almost no rabbits harbored ticks. In late spring nearly 75 per cent of the rabbits examined had ticks. In June, the number of infested rabbits dropped to 50 per cent or less. The number dropped again in late October and dwindled to almost zero by mid-November.

A larger number of larvae than nymphs and a larger number of nymphs than adults were found on rabbits in Lee County. Each tick must find a host three times during its life, and the decline in numbers of ticks between stages may be directly correlated with the chances involved in procuring hosts.

Larvae and nymphs of the continental rabbit tick often select ground-inhabiting birds as alternate, possibly equal, hosts. Adults of this tick rarely occur on birds; instead, they prefer rabbit hosts almost exclusively (Bishopp & Trembley 1945). Our records for for larvae and nymphs include such bird hosts as brown thrasher, towhee, prairie chicken, olive-backed thrush, tufted titmouse, quail, and swamp sparrow. Birds have been found infested as early in the year as April in central Illinois and as late as December in southern Illinois (INHS collection). Undoubtedly, migrating birds are responsible for dispersing some of these rabbit ticks northward in spring and southward in fall.

***Dermacentor variabilis* (Say); variable wood tick, wood tick, American dog tick; fig. 5.** – Insofar as numbers are concerned, the variable wood tick is a minor ectoparasite of rabbits. In Illinois it is the principal vector of Rocky Mountain spotted fever in man. The relationship of this tick to rabbits, to the disease organism that produces spotted fever, and to man is undoubtedly an important one. Price (1954) recently stated that the strains of *Rickettsia* virus that cause Rocky Mountain spotted fever in man are maintained in nature primarily in ticks of the genus *Dermacentor* rather

Fig. 5.—*Dermacentor variabilis*, variable wood tick, unengorged adult female. This tick is a vector of Rocky Mountain spotted fever. It was rarely found as an adult on rabbits in Lee County, Illinois, 1952-1954. In the immature stages, which were occasionally found on rabbits in Lee County, it can be distinguished from other Illinois rabbit ticks by the presence of eyes.

than in ticks of the genus *Haemaphysalis*. In contrast to the continental rabbit tick, which rarely bites man, the wood tick readily bites and engorges on man. In fact, the wood tick is the only tick in Illinois that is likely to attack a human being.

Larvae and nymphs of this tick prefer mice as hosts, although, in some areas and under certain conditions, rabbits are said to be important hosts for the immature stages (Eddy & Joyce 1944). Portman (1944) recorded that in southern Missouri larvae occur on rabbits in spring and even as early as January or February. Adults, which are not found frequently on rabbits (Smith *et al.* 1946), prefer larger mammals, for example, dogs (formerly, in all probability, coyotes and wolves), deer, raccoons, and opossums.

In Lee County, larvae and nymphs of the variable wood tick were found to infest rabbits, but only in limited numbers. Larvae were taken in May and nymphs in June and July. No adults were collected from any of the rabbits examined.

The reason the variable wood tick is associated in the early stages with rabbits, but not usually with them as a mature tick, is unknown at present. If it is not a matter of direct sensory reaction, it may be that the movement patterns of the adult tick and the rabbit do not coincide. Adults of this tick move to the edges of broad, bare pathways (large-animal trails) and roads (Smith *et al.* 1946) and climb the overhanging vegetation to await a host. It could be presumed, therefore, that only animals that frequent such avenues of travel would be apt to become infested by adults. Seemingly, rabbits do not often use pathways made by larger animals and, according to Stone & Cram (1902), they follow their own narrow runways. Furthermore, when rabbits come out to roadsides, they may not regularly move close to the overhanging grasses and herbs where the adult ticks wait. By contrast, dogs, wolves, and other large mammals are said to follow large-animal trails habitually and may often brush against the vegetation that harbors ticks.

Larvae and nymphs of the variable wood tick occur mostly away from roadsides and paths, according to Smith *et al.* (1946), and, although they usually select mice as hosts, they occasionally feed on rabbits.

Ixodes dentatus **Marx; eastern rabbit tick; fig. 6.** — As recently as 15 years ago, the eastern rabbit tick had not been reported from areas west of the Appalachian Mountains (Bell & Chalgren 1943). Cooley & Kohls (1945) gave the first midwestern record, a single female from Ames, Iowa. Ecke & Yeatter (1956) reported on the first Illinois specimens. We now have an additional Iowa record, a specimen from Edron, collected by Dr. Thomas G. Scott, and nine locality records from Illinois, fig. 7.

Fig. 6.—*Ixodes dentatus*, eastern rabbit tick, unengorged adult female. Adults of this species may be distinguished from adults of the other rabbit ticks in Illinois by the relatively long mouthparts (palps, indicated by arrow) and lack of scallops (festoons) around the posterior dorsal margin of the body. Determination of the immature stages can be made by using the key published in Cooley & Kohls (1945).

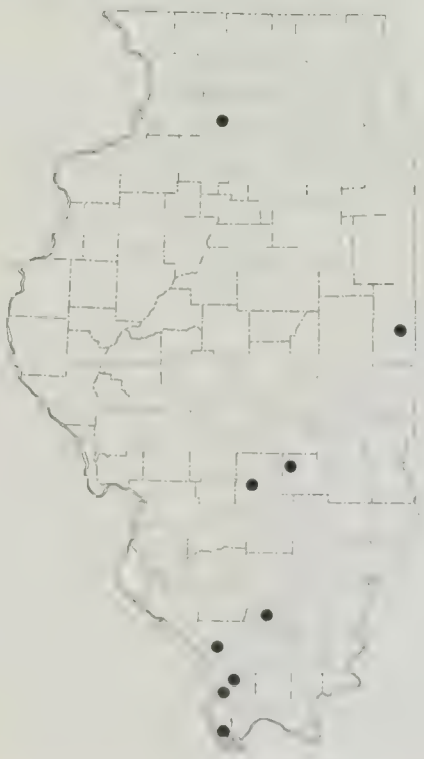

Fig. 7.—*Ixodes dentatus* distribution in Illinois, based on Illinois Natural History Survey records.

The life history of this tick was studied by Smith (1945) in Massachusetts. He found that, in the eastern United States, larvae hatch in July and August; that many of them and some of the resultant nymphs feed in the fall and hibernate through the winter; that those larvae and nymphs that do not feed in the fall feed in the spring and eventually transform into adults; and that fall-produced or spring-produced adults must undergo hibernation through a winter before the final feeding, mating, and egg laying can take place. Smith did not find this tick on rabbits in January or February. The seasonal cycle of this tick may be similar to the cycle of the continental rabbit tick.

The eastern rabbit tick is found to be fairly common on rabbits along the northeast Atlantic Coast. There, like the continental rabbit tick, it may occasionally attach to birds and sometimes, perhaps accidentally, to other mammals (Smith 1945).

This tick proved to be rare in Lee County. In our study, it was found on three rabbits: adults and larvae on two cottontails caught on May 8, 1953, and adults on one cottontail caught on June 4, 1954.

In the southern tip of Illinois, in 1934, Dr. Herbert H. Ross found nymphs and larvae active on rabbits as late as December 5.

***Ixodes sculptus* Neumann; ground squirrel tick.** – This tick is found primarily on ground squirrels and only incidentally on rabbits. It was recorded once in Illinois on rabbits from the central part of the state (Ecke 1948). We did not find it on rabbits in Lee County.

FLEAS

***Cediopsylla simplex* (Baker); common eastern rabbit flea; figs. 8 and 9.** – The common eastern rabbit flea is the second most numerous ectoparasite of cot-

Fig. 8.—*Cediopsylla simplex*, common eastern rabbit flea, adult female. The presence of a heavy comb of toothlike spines below the eyes distinguishes this species from *Odontopsyllus multispinosus*.

tontails, second only to the continental rabbit tick. Unlike the tick, which is generally absent in the winter, this flea is present on rabbits throughout the year in Lee County.

The life cycle and the numbers of generations of this flea per year are virtually unknown. Ewing & Fox (1943) stated that one specimen, reared in a vial, passed from the larval stage into the adult stage in less than 3 weeks in the month of April.

In general, the common eastern rabbit flea tends to concentrate on the rabbit around the area of the ears. It occurs also on the face, top of the head, and back of of the neck. In rare instances, this flea was found on the back, and occasionally it was taken from some other part of a rabbit's body.

Although we examined rabbits during only one entire spring season (1953), and our results should be checked against other collections made in the spring from a greater number of rabbits, perhaps it is worth while to note that a springtime increase of fleas of this species seems to occur on rabbits, fig. 10. In February, 1953, the average number of these fleas per rabbit infested had risen above the average number found in the preceding summer and fall. In March of the same year, a sharp increase in average number per rabbit occurred on the 11 rabbits examined. These fleas continued to be abundant during April and May on most of the small number of rabbits examined, table 3. For the entire study, the percentage of rabbits carrying these fleas was highest in the period beginning in November and ending in May and lowest in midsummer, table 3 and fig. 10.

Approximately 3,000 specimens of the common eastern rabbit flea were collected from rabbits in Lee

Fig. 9.—*Cediopsylla simplex*, adult male. In this sex, part of posterior protrudes conspicuously.

County. Of these, 1,882 individuals were females and 1,060 were males. This distribution of the sexes gives a ratio of 100 females to 56.3 males, or about 2 females to 1 male. Month by month, the ratio remained about the same. The number of males and females carried on any one rabbit varied from many females per male to more males than females. However, when the total population of fleas present on rabbits each season was considered, the same 2-to-1 ratio was observed, even in the springtime when the fleas were suspected to be most actively breeding. Shaftesbury (1934) found a similar ratio of sexes, 100 females to 56.1 males, for this flea in North Carolina. His figures are based on a small number of specimens, 189.

The highest number of common eastern rabbit fleas found on one rabbit was 101, collected March 25, 1953. This case was considered unusual; a few other rabbits harbored 70, 80, or even 90 fleas each, but most were less heavily infested. The average number of these fleas per rabbit examined was approximately 4. Some rabbits were found to have no fleas at all, but apparently such a condition is temporary.

Table 3.—Number of specimens of the common eastern rabbit flea, *Cediopsylla simplex*, taken from cottontails examined in Lee County, Illinois, and average number per rabbit infested; also, number and per cent of rabbits infested.

Month	Year	Rabbits			Fleas	
		Number Examined	Number Infested With Fleas	Mean Per Cent Infested With Fleas 1952–1954	Total Number Taken	Average Number Per Rabbit Infested, 1952–1954
January	1952	—	—		—	
	1953	9	8	90	43	5.7
	1954	1	1		8	
February	1952	—	—		—	
	1953	113	65	70	439	7.4
	1954	40	39		330	
March	1952	—	—		—	
	1953	11	11	100	366	33.3
	1954	—	—		—	
April	1952	—	—		—	
	1953	5	5	100	123	24.6
	1954	—	—		—	
May	1952	4	4		13	
	1953	12	8	75	205	18.2
	1954	—	—		—	
June	1952	52	27		104	
	1953	9	4	54	24	6.0
	1954	6	5		86	
July	1952	13	5		15	
	1953	63	24	40	100	4.0
	1954	4	3		15	
August	1952	15	11		24	
	1953	8	1	57	1	2.0
	1954	5	4		8	
September	1952	77	40		150	
	1953	—	—	52	—	3.7
	1954	—	—		—	
October	1952	74	37		181	
	1953	72	39	56	142	4.6
	1954	19	17		102	
November	1952	37	31		105	
	1953	38	36	90	202	4.9
	1954	26	25		147	
December	1952	—	—		—	
	1953	2	2	100	9	4.5
	1954	—	—		—	
TOTAL		715	452		2,942	

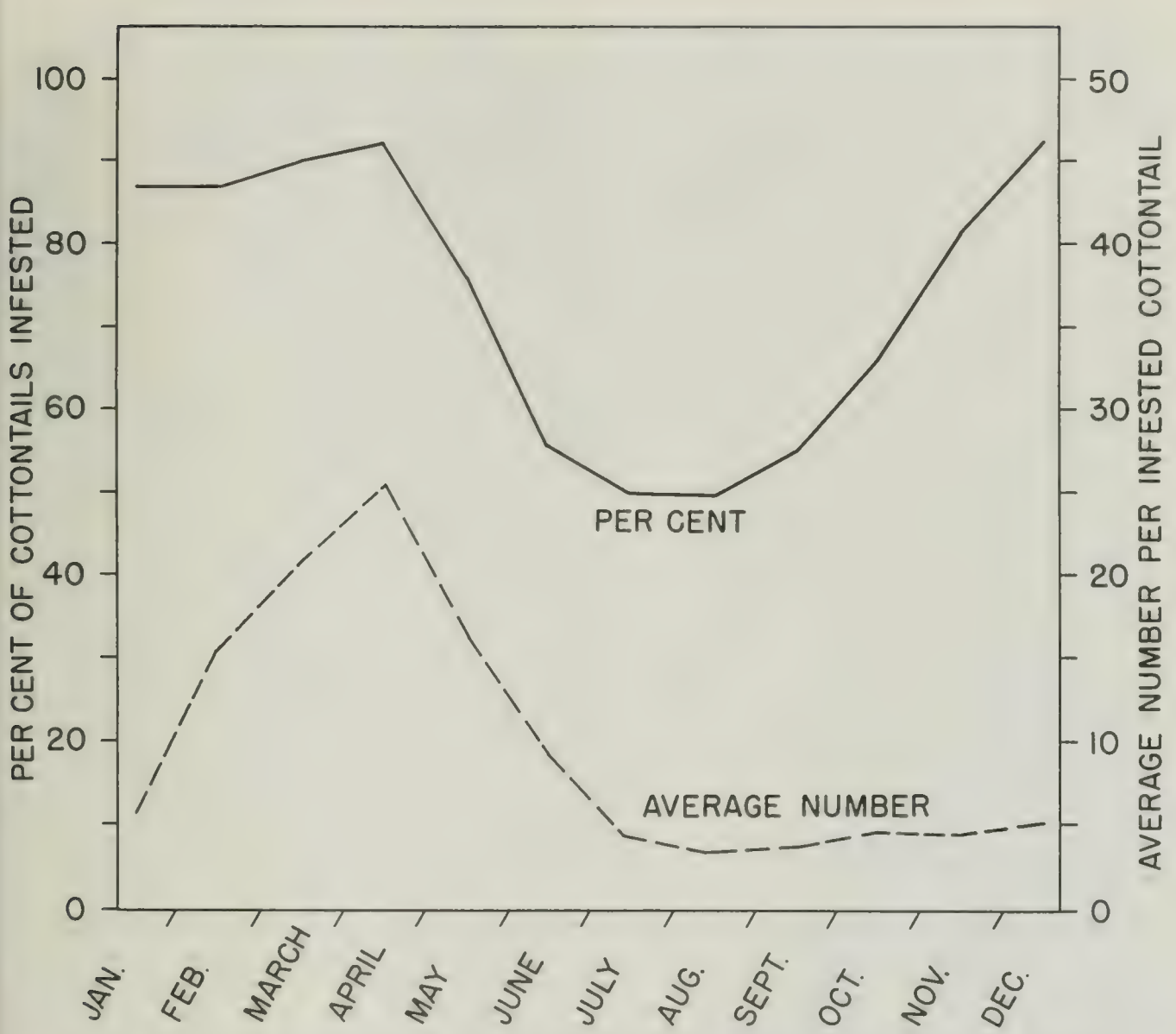

Fig. 10.—Monthly distribution (per cent of rabbits infested and average number on infested rabbits) of *Cediopsylla simplex* in Lee County, 1952-1954. The graph is based on 3-month sliding scale of data in table 3.

It is interesting to compare the apparent seasonal fluctuations in populations of this flea with populations of other species. Evans & Freeman (1950), in a survey of small mammals occurring near Oxford, England, found that: "For each species of host, the monthly indices point clearly to a rise, not only in the number of fleas per host, but also in the numbers of hosts infested, during the spring, with a maximum reached in the summer and a subsequent decline to a winter low. Such seasonal variation has been observed repeatedly, yet it is by no means clear how much this is due to a real decline in the numbers of fleas present in the breeding environment (the nests and burrows of the hosts), how much to a decrease in flea activity, or how much to changes in the numbers or activity of the host population." Recently, Holdenried *et al.* (1951) reported marked seasonal fluctuations in two species of fleas in California which have the same mammalian host. They found that the peak of abundance for one flea was in summer and the peak for the other was in winter.

Whatever may be the reason for the apparent abrupt increase in numbers of the common eastern rabbit flea on rabbits in Lee County in spring, the time of increase coincides, perhaps significantly, with the main breeding season of rabbits. Presumably, more occupied rabbit nests are present in spring than at any other time of year, a condition which is favorable for the development of a maximum number of larval fleas.

Because this rabbit flea has been previously recorded in print from only one Illinois locality (Kohls 1940), additional records are marked on the accompanying map, fig. 11, to demonstrate its state-wide occurrence on rabbits.

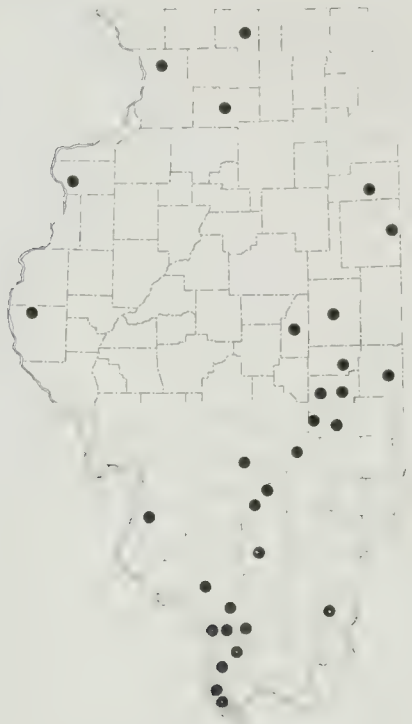

Fig. 11.—*Cediopsylla simplex* distribution in Illinois, based on Illinois Natural History Survey records.

***Odontopsyllus multispinosus* (Baker); giant eastern rabbit flea; fig. 12.** – The giant eastern rabbit flea is primarily an ectoparasite of cottontails. Here in Illinois and seemingly elsewhere, this insect is usually less numerous on rabbits than the smaller-sized common eastern rabbit flea. Nowhere throughout its range, from the east coast to about the 100th meridian, has the giant rabbit flea been found to be common. Shaftesbury (1934), in speaking of the North Carolina fauna, stated, "this latter species [*O. multispinosus*] might be relatively more abundant on some other kind of rabbit in some other locality." So far, no one has discovered this other kind of rabbit or this other locality. Rather, this flea appears to be the minor rabbit flea of eastern North America and may be scarce to rare on its rabbit host in all regions.

In Lee County, this flea was observed only on the backs of rabbits, and most of the specimens were from the lower backs. Apparently the two rabbit fleas divide their rabbit host into territories; that is, the common eastern rabbit flea occupies the front region, head and ears, whereas the giant eastern rabbit flea occupies the hind region.

The giant eastern rabbit flea was taken in Lee County during every season of the year. Ninety-six adult specimens were obtained from 12 rabbits. Inasmuch as more than 700 rabbits were examined, the 12 rabbits infested by this flea represent less than 2 per cent of the population studied. To our knowledge, and as measured by relative abundance, this flea is of little consequence as a rabbit ectoparasite, except perhaps on rare occasions. Once, in late February, 1953, we found a rabbit harboring 74 specimens. Usually each infested rabbit had only one, two, or three individuals of this flea.

In the collection of the Illinois Natural History Survey, specimens have been preserved from rabbits at Carbondale, Charleston, Cobden, Elkville, Starved Rock State Park, Urbana, and Vandalia, as well as in Lee County. The records given herein, fig. 13, constitute the first published records for Illinois.

***Opisocrostis bruneri* (Baker).** – Single specimens of this ground squirrel flea were taken from rabbits in Lee County on September 22, 1952, and on July 24, October 8, October 11, November 3, and November 8, 1953. This flea was once found on a cottontail in central Illinois in early April (INHS collection).

***Ctenophthalmus pseudagyrtes* (Baker).** – Although this flea is usually found on moles (Fox 1940), it infests many other small mammals, including cottontails. We collected this flea twice from cottontails in Lee County, once on January 2, 1954, and again on October 26, 1954.

***Orchopeas howardii* (Baker).** – Ordinarily, this flea occurs on tree squirrels. We have two records of it from rabbits, one from Lee County on February 14, 1953, and the other from central Illinois on May 5, 1948.

***Epitedia wenmanni* (Rothschild).** – This mouse flea was taken in Lee County from a cottontail on November 9, 1954.

BOT FLIES

***Cuterebra* spp.; bot fly; fig. 14.** – Bot fly larvae were occasionally noticed in open ruptures of the skin of rabbits, particularly in midsummer. In Lee County all but 1 of our 11 records of bot fly larvae were taken from rabbits in July; the exception, a large larva, was found on November 5, 1952. In summer both medium-sized and large larvae were found, even on the same day and on the same host.

***Cuterebra buccata* (Fabricius).** – Six of the bot fly larvae collected from rabbits in Lee County were provisionally determined as *Cuterebra buccata* by Dr. C. Sabrosky of the United States National Museum. One larva, of large size, collected from a rabbit in Lee County on July 9, 1953, pupated in soil provided for it

Fig. 12.—*Odontopsyllus multispinosus*, giant eastern rabbit flea, adult female. The absence of toothlike spines below the eyes and the presence of two rows of setae (instead of one row) on each abdominal tergite are features that distinguish this species from *Cediopsylla simplex*.

and emerged as an adult 2 months later, September 7. The reared adult was determined positively as *buccata*.

***Cuterebra cuniculi* (Clark) and *Cuterebra horripilum* Clark.** – In the collection of the Illinois Natural History Survey, there are six other specimens of bot flies; they were taken from Illinois rabbits in summer, 1883-1917. Some of these larvae are much larger in size than those found in Lee County and are presumably not *Cuterebra buccata*. Those that were reared to the adult stage were determined by the late C. T. Greene as *cuniculi*, a characteristically larger fly than *buccata*. According to our records, the pupa of *cuniculi*, unlike the pupa of *buccata*, spends about 10 months in the soil. One larva taken in Urbana on July 22, 1890, emerged as an adult on May 22, 1891. Another larva collected from the same locality on August 4, 1890, emerged May 19, 1891. Several of the specimens of *cuniculi* from central Illinois were from the neck region of cottontails.

One of the large unidentified bot fly larvae taken in Lee County may be *cuniculi* or the closely allied species, *horripilum*, rather than *buccata*.

CHIGGERS

***Euschöngastia peromysci* (Ewing); *Trombicula (Eutrombicula) alfreddugesi* (Oudemans); *Trombicula (Neotrombicula) whartoni* (Ewing).** – Chiggers infest a wide variety of mammal and bird hosts. On rabbits they are most commonly attached to the inside of the ears. They occur frequently on cottontails in central and southern Illinois, but apparently rarely in the northern part of the state. Where found in Illinois, *Trombicula (Neotrombicula) whartoni* infests cottontails in late autumn and winter, *Euschöngastia peromysci* in late winter, and *Trombicula (Eutrombicula) alfreddugesi* in late spring and summer.

Fig. 13.—*Odontopsyllus multispinosus* distribution in Illinois, based on Illinois Natural History Survey records.

No chiggers were taken on rabbits in Lee County; possibly they were overlooked.

CONCLUSIONS

Ectoparasites of cottontail rabbits, particularly the continental rabbit tick, *Haemaphysalis leporis-palustris*, are significant components of the wildlife of Illinois, and, as such, have had a decided effect on man's activities in recent years. Because of newly gained knowledge of the seasonal behavior of the continental rabbit tick on cottontails, the Illinois hunting laws were changed in 1955. Ecke (1948) and Yeatter & Thompson (1952) had shown conclusively, as we found during our studies in Lee County, 1952-1954, that those ticks which are vectors of tularemia are absent from rabbits in late fall and most of the winter in northern and central Illinois. Postponement of the hunting season until late fall to avoid the tick season and the consequent hazards of tularemia was the logical course of action which followed the reports of such information.

In our limited survey of ectoparasites of cottontails in Lee County, we observed the following fundamental features of the intricate relationships between ectoparasite and host: (1) Adults of the continental rabbit tick rarely feed on rabbits in fall. (2) Ticks and fleas reach their greatest abundance at different seasons of the year, as if each of the two groups gains an advantage by a division of time on the host. (3) The eastern rabbit flea, *Cediopsylla simplex*, occupies the head region of its host, whereas the giant eastern rabbit flea, *Odontopsyllus multispinosus*, occupies the back of its host, as if each of the species gains an advantage by eliminating competition for space. (4) The variable wood tick, *Dermacentor variabilis*, as an adult, is absent from rabbits when, in the same geographical region, it heavily infests other mammals such as opossums and raccoons. (5) Only two species of ectoparasites, the continental rabbit tick and the common eastern rabbit flea, are consistently numerous at certain seasons, whereas other ectoparasites, such as *Odontopsyllus multispinosus* and *Ixodes dentatus*, which are supposedly equally restricted and equally adjusted to rabbit hosts, remain relatively rare most of the time.

As is indicated by the aforementioned observations, the behavior patterns of ectoparasites of rabbits are extremely complicated. What factors, it may be asked, could cause one of the two ticks and one of the two fleas restricted to rabbits to be common and the others to be rare? Or what factors could cause the adult of the variable wood tick to infest almost every mammal the size of a rabbit or larger, but not be found on rabbits? Why do the ticks that are primarily ectoparasites of rabbits feed in the adult stage only on rabbits, yet in the immature stages find birds as acceptable as rabbits?

Surveys such as ours cannot provide answers to many questions; rather, they provide a few facts that suggest further questions. Thorough and detailed investigations of the life history and environment of each ectoparasite and the habits and environment of the host need to be undertaken and correlated before much can be deduced as to the origins and the conditions for optimal survival of ectoparasites.

Ectoparasites of cottontail rabbits, because they are easy to obtain and because preliminary studies on them have been made here and elsewhere, are worthwhile subjects for future research.

SUMMARY

Seven facultative or obligate ectoparasites were taken from about 700 cottontail rabbits collected in Lee County, northern Illinois, in a period beginning in May, 1952, and ending in November, 1954.

The continental rabbit tick, *Haemaphysalis leporis-palustris*, the principal vector of tularemia, was the most common tick found. Very few specimens were collected from rabbits from late autumn to late winter.

Adults of this tick were collected from rabbits from late winter to midsummer. They reached their greatest abundance on cottontails in spring. The adults rarely infested rabbits in autumn or early winter; they were

Fig. 14.—*Cuterebra* sp., bot fly larva, dorsolateral view. Actual size about 1-1/4 inches.

present, however, in leaf mold, even before cold weather set in.

Larvae of this tick apparently suffered high losses during winter, and few were found in spring. In midsummer, larvae of the new generation hatched and then reached the peak of their abundance on rabbits in August and September.

Nymphs of the new generation reached their peak of abundance on rabbits in September and October. Unlike larvae, nymphs commonly survived the winter and reappeared fairly abundantly on rabbits in early spring.

The proportion of rabbits infested with the continental rabbit tick, in any stage, varied with the season. Ninety per cent of the rabbits examined harbored this tick in August and September, 0 per cent in midwinter, 75 per cent in spring, and 50 per cent in early summer.

The variable wood tick, *Dermacentor variabilis*, the principal vector in Illinois of Rocky Mountain spotted fever, was found principally in spring, and even then not commonly. Possibly because of the behavior patterns of this tick and the rabbit, only larvae and nymphs were found feeding on cottontails in Lee County.

The eastern rabbit tick, *Ixodes dentatus*, although almost exclusively restricted to rabbits, was found to be rare on cottontails in Lee County.

The common eastern rabbit flea, *Cediopsylla simplex*, was the flea most often collected. It was found primarily around the head and neck region of rabbits. This flea infested cottontails throughout the year; it was most abundant in early spring and least abundant in late summer. It was observed to have a sex ratio of about 2 females to 1 male. The largest number of fleas of this species found on one rabbit was 101; the average per rabbit examined was approximately 4. On a few rabbits no fleas were found.

The giant eastern rabbit flea, *Odontopsyllus multispinosus*, which seemed to prefer to feed on the hind regions of cottontails, was taken occasionally at all seasons. It was not found to be abundant except in rare instances.

Fleas of four additional species normally found on other mammals were taken several times on cottontails in the Lee County study area. These specimens had probably strayed to rabbits accidentally.

Cuterebra buccata was the principal bot fly obtained from cottontails in Lee County. Larvae were found, mostly during the summer, in open ruptures of the skin of rabbits. One of the large unidentified larvae may prove to be *cuniculi* or *horripilum*.

No chiggers were found on the rabbits examined.

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